HEMMING APPARATUS AND METHOD

This application claims the benefit of and hereby expressly incorporates by reference U.S. Provisional Application Serial No. 60/141,434, filed on June 29, 1999.

Background of the Invention

Field of the Invention

The present invention relates to the hemming arts. More particularly, the present invention relates to improvements in a hemming apparatus and an improved method for hemming sheet metal or like material together. The present invention finds particular application in the automotive field and will be described with particular reference thereto. However, it is to be appreciated that the present invention is also amenable to other like applications.

Discussion of the Art

In the automotive field it is often desirable to join two pieces of sheet metal together in a hemming operation to form a door, hood, trunk deck, or other such component. Generally, a unitary outer skin of sheet metal is hemmed to a second inner reinforcing panel of sheet metal. Hemming involves bending and compressing a generally upturned or perpendicular flange located along each edge of the outer sheet over an adjacent edge of the inner panel. It is important that the hemming results in a firm, vise-like grip of the flanges of the inner panel between the outer panel and its marginal flanges and that

the shape and dimensions of the overall assembly are held within prescribed tolerances.

In the prior art, such hemming has often been accomplished in two separate stages often using two sets of dies mounted in two successive presses. The inner reinforcing panel is nested within the unitary outer panel which is fixtured on an anvil die on a base of a prehemming machine. Upon fixturing the assembly, a tool of the machine, commonly referred to as a hemming steel, engages and bends an edge of the outer panel to an acute included angle with respect to the outer panel. Prehemming is sometimes referred to as "fortyfive-ing" because the angle of the flange becomes about forty-five degrees with respect to the general plane of the outer panel. After prehemming all edges to be joined, both panels are released, transferred to, and fixtured in a second hemming machine where a second steel completely bends the prehemmed edge of the outer panel over the peripheral edge of the reinforcing panel to secure and attach the panels together as a unitary structural member for assembly on a vehicle. This second stage is often referred to as full-hemming.

An obvious disadvantage of the two-stage, two-machine system is the need for two machines which require a significant amount of floor space as well as time and labor resources required for moving the assembly out of one press and into the second press. Because of these disadvantages, the two-stage, two-press system was improved upon and eventually evolved into a single station, two press system where prehemming and full-hemming occur without the need for re-fixturing the assembly between stages. Typically, a plurality of both prehemming and final hemming machines were respectively grouped around the periphery of a panel to perform all prehemming and full-

hemming operations for one assembly either sequentially or substantially simultaneously.

After further improvements, hemming machines were designed to perform both the prehem and final hem operation in a single station, single machine system. Hemming machines of this type vary in the kind of mechanism used and the manner of carrying out the hemming operations.

One group includes machines having linkage driven steels, machines having one rotary steel driven by another linear driven steel, and machines having one steel telescopingly hem from within the prehemming steel. Representative of this group are the following patents: U.S. Patent No. 1,693,643 to D'Ardenne, U.S. Patent No. 5,404,742 to Wilson et al, and U.S. Patent No. 3,903,934 to Vizy.

Another group includes machines having steels that traverse generally linearly in one or two directions. hemming machines of this type, such as U.S. Patent No. 3,143,095 to Tribe, may have a prehemming steel traversing across the general plane of the outer skin and a full-hemming steel traveling perpendicular to the plane of the outer skin. The obvious disadvantage of this type of machine is that it requires two steels or dies, two directions of travel, extra cycle time for two operations, and a substantial amount of space around the assembly which prevents the hemming of internal edges. Alternatively, machines, such as U.S. Patent No. 5,315,855 to Jackson, use a single steel traversing in only the plane of the outer skin have been disclosed but still require a substantial amount of space preventing internal hemming and often result in a hem that is not firm, out of tolerance, and of low visual quality. Finally, there are machines, such as U.S. Patent No. 1,961,582 to Eksergian, that travel only

perpendicular to the general plane of the outer skin but still require substantial space around the assembly, two steels, and do not create a quality hem.

Therefore, it is desirable to provide an improved apparatus and method for hemming sheet material together. The present invention contemplates such an invention that overcomes many of the problems of the prior art and others.

Brief Summary of the Invention

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In accordance with the present invention, an improved apparatus and method for prehemming and hemming is provided for minimizing the above-referenced and other disadvantages of the prior art, and in particular, for folding an edge portion of a curved arcuate panel to create a hem in a single cycle of operation with a single hemming swing steel pressed only in the vertical direction.

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In accordance with one aspect of the present invention, a hemming apparatus for hemming an outer skin and inner panel together is provided. The apparatus includes an anvil for supporting an associated assembly. The assembly comprising the outer skin and the inner panel. The apparatus additionally includes an upper body and a steel mounted to the upper body. The steel is adapted for movement between first and second operative positions. Furthermore, the steel has a first angled surface for prehemming the assembly when the steel is in the first operative position and a second angled surface for full-hemming the assembly when the steel is in the second operative position.

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In accordance with another aspect of the present invention, a method for hemming an outer skin and inner panel together is provided. It includes placing an

assembly on a supporting surface of an anvil. The assembly comprising an inner panel positioned on an outer skin where the inner panel has a peripheral edge and the outer skin has a peripheral flange. It next includes moving a hemming steel, while in a first operative position, in a first direction into the peripheral flange of the outer skin so that an angled prehemming surface of the steel deforms the flange toward the inner panel thereby prehemming the assembly. The hemming steel is further moved in the first direction moving the hemming steel into a second operative position. Meanwhile, the steel moves into the deformed peripheral flange so that a hemming surface of the steel engages the deformed flange and moves it into close contact with the inner panel thereby full-hemming the assembly. Finally, the steel is moved away from the hemmed assembly and removing the finished assembly from the supporting surface.

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One advantage of the present invention is the provision of a hemming apparatus that requires only one steel reducing the construction costs of the machine and the maintenance costs of the steel.

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Another advantage of the present invention is the provision of a hemming apparatus that substantially reduces the risk of the die "smashing" because the machine will only use one steel to contact the peripheral edge of the assembly.

Another advantage of the present invention is the provision of a hemming apparatus that lacks many complex and moving components.

Another advantage of the present invention is the provision of a hemming apparatus that uses only vertical press motion which prevents compression of the outer, and more visual, skin. Preventing such compression eliminates

or reduces unsightly buckling or waves caused by overruns on the inner skin.

Another advantage of the present invention is the provision of a hemming apparatus that only requires a vertical, mechanical press for operation.

Another advantage of the present invention is the provision of a hemming apparatus that requires only one stroke of a mechanical press to produce a complete hem.

Another advantage of the present invention is the provision of a hemming apparatus that may be used in places such as window openings, gas cap openings, and the like.

Another advantage of the present invention is the provision of a hemming apparatus that substantially reduces the number of weld spots typically required for an entire assembly.

Still further advantages and benefits of the present invention will become apparent to those of ordinary skill in the art upon reading and understanding the following detailed description.

Brief Description of the Drawings

The structure, operation and advantages of the presently preferred embodiment of this invention will become further apparent upon consideration of the following description, taken in conjunction with the accompanying drawings. Of course, the drawings are only for purposes of illustrating preferred embodiments and are not to be construed as limiting the invention.

FIG. 1a is a cross-sectional view of two sheets prior to prehemming and full-hemming in accordance with aspects of the present invention;

FIG. 1b is a cross-sectional view of the two sheets depicted in FIG. 1a after prehemming and before

full-hemming in accordance with aspects of the present invention;

FIG. 1c is a cross-sectional view of the two sheets depicted in FIG. 1a after prehemming and full-hemming in accordance with aspects of the present invention;

FIG. 2 is a diagrammatic view showing a preferred embodiment of a hemming apparatus in accordance with aspects of the present invention;

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FIG. 3 is a diagrammatic side view of a prior art two-steel, two-directional hemming apparatus and its related compression forces;

FIG. 4 is a diagrammatic view of the hemming apparatus shown in FIG. 2 and its related compression forces in accordance with aspects of the present invention;

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FIG. 5 is a diagrammatic view of an alternate embodiment of a steel in accordance with aspects of the present invention;

FIG. 6a is a diagrammatic view showing an alternate preferred embodiment of a hemming apparatus in accordance with aspects of the present invention;

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FIG. 6b is a diagrammatic view of the hemming apparatus shown in FIG. 6a showing the steel in a first position prehemming an assembly; and

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FIG. 6c is a diagrammatic view of the hemming apparatus shown in FIG. 6a showing the steel in a second position full-hemming the assembly.

Detailed Description of the Invention

Referring now to the drawings wherein like reference characters represent like elements, the showings

are for purposes of illustrating preferred embodiments of the invention only and not for purposes of limiting the same. The improved hemming apparatus and method described in the description below accurately and speedily carries out an entire prehemming and clinching/full-hemming operation in one cycle and supplies firmly clinched flanges without affecting the dimensional accuracy or the visual appearance of the finished product.

With reference to FIGS. 1a-1c, an assembly is generally indicated by reference numeral **10**. The assembly **10** includes two elements of pressed sheet metal or other suitable material respectively constituting the unitary outer skin **12** and the inner reinforcing panel **14** of a motor vehicle assembly. The assembly **10** may be, without limitation, a motor vehicle door, hood, trunk deck or other component. The assembly **10** rests on a fixed supporting structure or anvil **16**. The anvil **16** has a horizontal supporting surface **18** for positioning and supporting the outer skin **12** and the inner panel **14**.

FIGS. 1a-1c depict the sequential movement and resulting position of the assembly **10** during a hemming operation. With specific reference to FIG. 1a, the outer skin **12** and the inner panel **14** are shown at rest prior to the hemming operation. The underlying outer skin **12** has a peripheral flange **12a** arranged substantially at ninety degrees with respect to the anvil supporting surface **18** and is offset slightly from distal end of the peripheral edge **14a** of the overlying inner panel **14** as is well known.

With specific reference to FIG. 1b, the outer skin **12** and the inner panel **14** are shown after the first step or prehemming step of the hemming operation. In this step, the peripheral flange **12a** of the outer skin **12** is

bent forty-five degrees relative to its starting position in the direction of the inner panel **14**.

With specific reference to FIG. 1c, the outer skin **12** and the inner panel **14** are shown after the clinching or full-hemming step. In this step, the peripheral flange **12a** of the outer skin **12** is bent further and now is arranged at about ninety degrees relative to its initial position. The peripheral flange **12a** is superimposed and pressed against the peripheral edge **14a** creating a joint between the outer skin **12** and the inner panel **14**. Many such joints may exist on a single assembly **10** and are generally located about the periphery edges of the outer skin **12** and the inner panel **14**. Joints may even be located at interior locations on the assembly **10** such as a window or gas cap recess.

With reference to FIG. 2, a hemming apparatus **15** includes a lower body or anvil **20** having a major supporting surface **22** for supporting the unitary outer skin **12** and the inner reinforcing panel **14**. The inner panel **14** is positioned on the outer skin **12** with its edge **14a** slightly offset from the peripheral flange **12a**. The flange **12a** is arranged substantially at ninety degrees with respect to the anvil supporting surface **22**. The peripheral flange **12a** on the outer skin **12** rests directly along one edge **24** of the anvil **20**. The same edge **24** of the anvil **20** is adjacent to a sloping side **26**, angled at forty-five degrees in the preferred embodiment of the invention.

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The hemming apparatus **15** additionally includes an upper body **27** as either a connected or separate component. The upper body **27** is mounted to a vertical press (not shown) as is well known. The upper body **27** holds the swing

tool or steel **28** formed in accordance with the present invention by means of a screw **30** or the like. Steel **28** is constructed of a suitable material with an appropriate hardness as is well known. The steel **28** has a round or rounded upper surface **32** which nestles inside a curved recess **34** of the upper body **27** such that the steel **28** may pivot outward from the upper body **27**. An inner side **36** of the steel **28** rests against the keeper or extended portion **38** of the upper body **27**. The outer or exposed side **40** is open and held in place by a spring **42** or other biasing means. The spring **42** is a blue medium duty die spring with a strength of 216 lbs. in the preferred embodiment. Of course, other suitable springs may be used.

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The bottom surface of the steel **28** has two angled surfaces **50** and **52** defined at angles α and β, respectively. Angles α and β are relative to respective planes positioned parallel to the supporting surface **22**. The prehemming angled surface **52**, extends from the bottom open edge **44** of the steel **28** inward and upward to the approximate center **46** of the steel **28** at an angle α which is equal to that of the sloped side **26** of the anvil **20**. Full-hemming angled surface **50** extends from the closed, bottom edge **48** of the steel **28** inward and downward at angle β to the approximate center **46** of the steel **28** meeting prehemming angled surface **52**. The magnitude of angle β is such that when the steel **28** is forced vertically downward to its farthest position at which point the steel **28** is pivoting against the spring **42**, angled surface **50** will rest parallel to the supporting surface **22** of the anvil **20**.

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In operation, the upper body **27** moves the steel **28** downward in a first operative position to contact the

peripheral flange **12a** of the outer skin **12** and the sloping side **26** of the anvil **20**. The upper body **27** is powered by a vertical press as is well known but other suitable driving means may be employed. When the steel **28** first contacts the peripheral flange **12a**, the flange **12a** will bend inward toward the inner panel **14** until the prehemming angled surface **52** of the steel **28** contacts the sloping side **26** of the anvil **20**. At this point, the steel is still in the first operative position and the bend in the peripheral flange **12a** is at angle α relative to the supporting surface **22** of the anvil **20**. Thus, the prehemming of the peripheral flange **12a** to the inner panel **14** is complete.

As the upper body **27** continues to move the steel **28** downward, i.e., toward the anvil support surface **22** and a second operative position, the steel **28** is forced to pivot from the upper body **27** at the screw **30** against the force of the spring **42** owing to the prehemming surface **52** of the steel **28** slidably engaging the sloping side **26** of the anvil **20**. The stiffness of the spring **42** is such that steel **28** is generally secured against upper body **27**, including during the prehemming operation, but gives appropriately when the steel **28** is forced to pivot against sloping side **26** of the anvil **20**. The steel **28** will continue pivoting and moving downward until the full-hemming angled surface **50** is substantially parallel to the supporting surface **22** of the anvil **20**. At this point, the steel is in the second operative position and the peripheral flange **12a** of the outer panel **12** and the inner panel **14** are completely hemmed.

In a preferred embodiment, the peripheral flange **12a** will be arranged at about ninety degrees with respect

to its initial position so that it is superimposed and pressed against the peripheral edge **14a**. The upper body **27** is then retracted upwards, moving the steel **28** upward and away from the hemmed outer skin **12** and inner panel **14**. Of course, the spring **42** or other biasing means moves the steel **28** to its home or first operative position illustrated in FIG. 2. The outer skin **12** and inner panel **14** together form a complete hemmed assembly **10** which may now be removed from the anvil **20**. Thus, the apparatus **15** will have only used one cycle of a vertical press to complete both the prehemming and full-hemming operations. Several steels **28** may be employed simultaneously and powered by a single vertical press. In such an arrangement, several hems are completed upon one stroke of the vertical press.

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An important aspect of the present invention relates to its ability to substantially reduce undesirable compression forces typically exerted on the peripheral flange **12a** in prior art hemming machines. Referring to FIG. 3, previously known devices often use a two-steel, two-stage process or other similar process to hem the outer skin **12** to the inner panel **14**. Prehemming is accomplished when a horizontal steel **54** moves toward the assembly **10** and engages the peripheral flange **12a**. Horizontal steel **54** continues and forces peripheral flange **12a** to bend inward toward supporting surface **22** of the anvil **20** until horizontal steel surface **54a** meets sloping surface **26**.

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Such a prehemming process is problematic because horizontal steel **54** begins forcing peripheral flange **12a** to bend against the peripheral edge **14a**. Thus, the skin **12** exerts a force on the panel **14** during the bending. Between the force of horizontal steel **54** and the immobile

resistance of anvil **20**, this force causes either the outer skin **12** or the inner panel **14** to buckle producing an undesirable and rough finish. The vertical steel **56** completes the hem by full-hemming the peripheral flange **12a** to the peripheral edge **14a** but the unsightly buckle remains in the outer skin **12** or the inner panel **14**.

Referring to FIG. 4, the present invention uses only vertical motion to complete the hemming operation in contrast to the prior art. The upper body **27** moves the steel **28** downward toward the peripheral flange **12a**. When the tool **28** engages the peripheral flange **12a** and begins bending the peripheral flange **12a** inward and downward toward the supporting surface **22** of the anvil **20**, the force **C** applied to the peripheral flange **12a** is substantially downward. The buckling problem of the prior art is absent because the peripheral flange **12a** is allowed to move out toward the slope side **26** of the anvil **20**. Thus, the finished hem has a desirable finish without any unsightly buckles.

Optionally, an adhesive may be applied to the peripheral flange **12a** of the outer skin **12** and to the peripheral edge **14a** of the inner panel **14** prior to hemming to enhance the integrity of the hem. The adhesive seals and firms the hem and enhances some or all of the advantages of the present invention.

Alternately, with additional reference to FIG. 5, the steel **28** may include an indented radius **60** located along the intersecting edge between the full-hemming angled surface **50** and prehemming angled surface **52**. The radius **60** provides clearance between the steel **28** and the assembly **10** during the movement of the steel **28** from the first operative position where prehemming occurs and the second

operative position where full-hemming occurs. Such clearance decreases the likelihood of the steel **28** damaging the peripheral flange **12a** and edge **14a** during the transition between the two positions.

With reference to FIGS. 6a-6c, a hemming apparatus **100** is shown according to an alternate preferred embodiment of the present invention. The apparatus **100** includes an anvil **20** having a major supporting surface **22** for supporting the unitary outer skin **12** and the inner reinforcing panel **14**. The supporting surface **22** is angled approximately twelve degrees relative to the vertical face **102** of the anvil **20**. The outer skin **12** rests on the supporting surface **22** with the inner panel **14** positioned on the outer skin **12**. The outer skin **12** includes a peripheral flange **12a** which extends away from and perpendicular to the supporting surface **22**. The peripheral flange **12a** is positioned at or near one edge **24** of the anvil **20**. Adjacent the supporting surface **22** is a sloping side **26** which extends at a forty-five degree angle relative to the supporting surface **22**.

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The hemming apparatus **100** includes an upper body **27**. The upper body **27** is mounted to vertical press by means of a die shoe and a machine steel sub plate as is well known. The upper body **27** holds a steel **28** formed in accordance with the present invention. The steel **28** has a rounded upper surface **32** which nestles inside a curved recess **34** of the upper body **27**. An inner side **36** of the steel **28** rests against an extended portion **38** of the upper body **27**.

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The apparatus **100** additionally includes a spring housing **104** that encloses a medium or heavy duty die spring

42. The housing **104** is adapted to receive a preload spacer **106** at a distal end of the spring **42** and includes a spring cap **108** for forcing the spring **42** against the steel **28**. The preload spacer **106** may vary and serves the purpose of allowing for variable adjustment of the resistance of the spring **42**. A plurality of roller bearings **110** are also provided and secured to the steel **28** by a connecting means **111**. Roller bearings **110** engage a cam **114** mounted to the anvil **20** upon actuation and movement of the vertical press toward the anvil **20** so that roller bearings **110** travel on the cam **114** and move the steel **28** into its second operative position. The steel **28** is shown in a first position prior to actuation and movement by the vertical press.

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Similar to the first preferred embodiment, the steel **28** has two angled surfaces, a prehemming surface **52** and a full-hemming surface **50**. The respective angles of the surfaces **50** and **52** are calculated as described above. The prehemming surface **52** is at an angle approximately equal to that of the sloping side **26** and the hemming surface **50** is at an angle adapted to provide a full hem upon pivotal movement of the steel **28**.

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In operation, the upper body **27**, powered by the vertical press, moves the steel **28** toward the peripheral flange **12a** of the outer skin **12**. The steel **28** is initially in a first or resting position, i.e., the steel **28** is urged against the extended portion **38** by the spring **42**. The steel **28** will contact and bend the peripheral flange **12a** inward toward the inner panel **14** until the roller bearings **110** engage the cam **114**. With reference to FIG. 6b, the bend in the peripheral flange **12a** is at an angle approximately equal to the sloping side **26** of the anvil **20**

and the roller bearings **110** are fully engaged with the cam **114**. Thus, the prehemming of the peripheral flange **12a** is complete. At this point, the engagement between the roller bearings **110** and the cam **114** prevent the prehemming surface **52** of the steel **28** from moving any further into the peripheral flange.

Further movement by the vertical press forces the steel **28** to pivot against the spring **42**. The roller bearings **110** move along the cam **114** and the steel **28** pivots from a first position to a second position. During the transition from the first position to the second position, the full-hemming surface **50** of the steel **28** engages and moves the peripheral flange **12a** of the outer skin **12**. The full-hemming surface **50** continues to bend the peripheral flange **12a** toward the inner panel **14** until the flange **12a** is superimposed and pressed against the peripheral edge **14a** of the inner panel **14**. At this point the steel **28** is in its second operative position and the assembly is fully hemmed (FIG. 6c). As in a previous embodiment, the vertical press may be reversed to remove the steel **28** from the hemmed assembly **10** and the hemmed assembly **10** may be removed.

The invention has been described with reference to the preferred embodiments. Obviously, modifications and alterations will occur to others upon reading and understanding the preceding detailed description. It is intended that the invention be construed as including all such modifications and alterations insofar as they come within the scope of the appended claims or the equivalents thereof.